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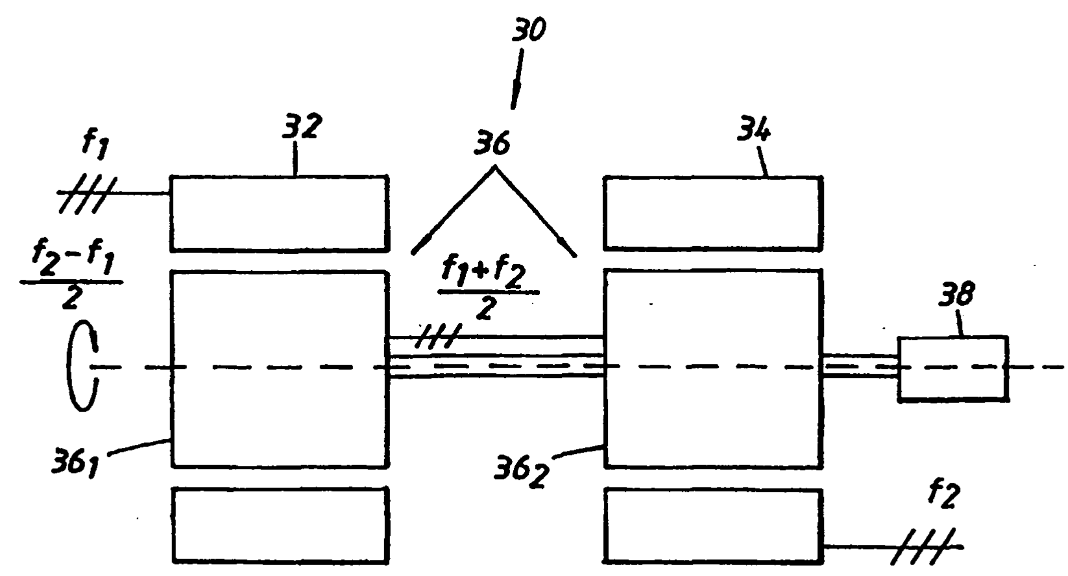

(57) Abstract

The present invention relates to a rotating asynchronous converter and a generator device. The converter comprises a first stator connected to a first AC network with a first frequency (f_1), and a second stator connected to a second AC network with a second frequency (f_2). The conv rter also comprises a rotor means which rotates in dependence of the first and second frequencies (f_1, f_2). The stators each comprise at least one winding, wherein each winding comprise at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and n the other hand between them is arranged a solid insulation.

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A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE

Technical field of the invention

The present invention relates to a rotating asynchronous converter in accordance with the introductory part of Claims 1, 10, and 19, and the use of such converter.

The present invention also relates to a generator device in accordance with the introductory part of Claims 20 and 29.

Background of the invention

In a number of situations exchange of power must be performed between AC networks with different or at least not synchronous frequencies. The most frequent cases are the following:

1. Connection of not synchronous three phase networks with equal rating frequencies, e.g. between eastern and western Europe.
2. Connection of three phase networks with different frequencies, most usually 50 Hz/60 Hz (e.g. Japan, Latin America).
3. Connection of a three phase network and a low frequency, one/two phase network for railway supply, in Europe 50 Hz/16.2/3 Hz, in USA 60 Hz/25 Hz.
4. The use of rotating asynchronous converters as a series compensation in long distance AC transmission.

Today, the connection is performed with the aid of power electronics and DC intermediate link. In the above mentioned cases 2 and 3 the connection can further be performed with the aid of matrix converters. In case of synchronous, but different frequencies in the above mentioned cases 2 and 3 the connection can further be performed with the aid of rotating converters comprising mechanically connected synchronous machines.

In the article, "Investigation and use of asynchronized machines in power systems", Electric Technology USSR, No. 4, pp. 90-99, 1985, by N.I. Blotskii, there is disclosed an asynchronized machine used for interconnection of power systems, or their parts, which

have different rated frequencies, or the same rated frequencies, but differing in the degree of accuracy with which it must be maintained. The structure of the asynchronized machine is disclosed in figure 1. The asynchronized machine includes an electric machine 1 which is a machine with a conventional three-phase stator and either a non-salient-pole symmetrical rotor or a salient-pole or non-salient-pole electrically asymmetrical rotor, the phase leads being connected to slip rings; an exciter 2 which is a cycloconverter or reversing controlled rectifier, the cycloconverter supply 3 or 4, a regulator 5 forming the control law required for the rotor ring voltages and the main machine rotor angle and speed 6, voltage 7 and current 9 sensors of the stator and rotor.

In the article, "Performance Characteristics of a Wide Range Induction type Frequency Converter", IEEMA Journal, Vol. 125, No. 9, pp. 21-34, September 1995, by G.A. Ghoneem, there is disclosed an induction-type frequency converter as a variable frequency source for speed control drives of induction motors. In figure 2 there is disclosed a schematic diagram of the induction-type frequency converter. The induction-type frequency converter consists of two mechanically and electrically coupled wound rotor induction machines A, B. The stator windings of one of them (A) are connected to 3-phase supply at line frequency (Vi, Fi), while the stator windings of the other machine (B) represent the variable frequency output (Vo, Fo). The rotor windings 10, 12 of the two machines are connected together with special arrangement. The converter is driven by a variable speed primemover 14, a DC motor can be used.

Static converters have drawbacks such as relatively low efficiency (ca 95%) owing to the losses in the semi-conductors, harmonics which have to be compensated with the aid of filters. The use of DC intermediate links leads to the use of special converter transformers with very complex design. The fillers are leading to a great need of space for the total assembly. Conventional rotating

converters are not designed for high voltages, so a transformer is needed at each side for the connection to the AC network. The efficiency then becomes comparable to or even lower than the efficiency of a static converter.

Summary of the invention

The object of the invention is to solve the above mentioned problems and to provide a rotating asynchronous converter for connection of AC networks with equal or different frequencies. This object is achieved by providing a rotating asynchronous converter defined in the introductory part of Claim 1, 10, or 19 with the advantageous features of the characterizing part of said Claims.

Accordingly, the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2. At least one of the stators each comprise at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

According to another embodiment of the converter, it comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of said fist and second frequencies f_1, f_2. The stators each comprise at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor, each conductor comprises a number of strands, around said conductor is arranged an inner semiconducting layer, around said inner semiconducting layer is arranged an insulating layer of solid insulation,

and around said insulating layer is arranged an outer semi-conductor layer.

According to another embodiment of the converter, it comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of said first and second frequencies f_1, f_2. The stators each comprises at least one winding, wherein each winding comprises at least one currect-carrying conductor. Each winding also comprises an insulation system, which in respect of its thermal and electrical properties permits a voltage level in said rotating asynchronous converter exceeding 36 kV.

A very important advantage of the present invention as defined in Claim 1, 10, or 19, is that it is possible to achieve a connection of two not synchronous networks without the further use of transformers or any other equipment. Another advantage is the high efficiency, which is expected to be 99%.

By designing the insulation system, which suitably is solid, so that it in thermal and electrical view is dimensioned for voltages exceeding 36 kV, the system can be connected to high voltage power networks without the use of intermediate step-down-transformers, whereby is achieved the above referenced advantages. Such a system is preferably, but not necessarily, designed in such a way that it comprises the features of the rotating asynchronous converter according to any one of Claims 1-19.

Another object of the invention is to solve the above mentioned problems and to provide a generator device with variable rotational speed. This object is achieved by providing a generator device deined in the introductory part of Claim 20 or 29 with the advantageous features of the characterising parts of said Claims.

Accordingly, the generator device comprises a stator connected to an AC network with a frequency f_2, a first cylindrical rotor connected to a turbine, which rotates

with a frequency f_1. The generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2. The stator and the first cylindrical rotor each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

According to another embodiment of the generator device, it comprises a stator connected to an AC network with a frequency f_2, and a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1. The generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2. The stator and the first cylindrical rotor each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor, each conductor comprises a number of strands, around said conductor is arranged an inner semiconducting layer, around said inner semiconducting layer is arranged an insulating layer of solid insulation, and around said insulating layer is arranged an outer semiconducting layer.

The above mentioned and other preferable embodiments of the present invention are specified in the dependent Claims.

In a certain aspect of the present invention it relates to the use of the invented asynchronous converter in specific applications such as those specified in Claims 38-41, in which applications the advantages of the invented device are particularly prominent.

Embodiments of the invention will now be described with a reference to the accompanying drawings, in which:

Brief description of the Drawings

Figure 1 shows a schematic diagram of an asynchronized machine used for interconnection of power system according to the state of the art;

Figure 2 shows a schematic diagram of an induction-type frequency converter as a variable frequency source according to the state of the art;

Figure 3 shows the parts included in the current modified standard cable;

Figure 4 shows a first embodiment of a rotating asynchronous converter according to the present invention;

Figure 5 shows a second embodiment of the rotating asynchronous converter according to the present invention;

Figure 6 shows a first embodiment of a generator device according to the present invention ; and

Figure 7 shows a second embodiment of the generator device according to the present invention.

Detailed description of Embodiments

A preferred embodiment of the improved cable is shown in Figure 3. The cable 20 is described in the figure as comprising a current-carrying conductor 22 which comprises transposed both non-insulated and insulated strands. Electromechanically transposed, extruded there is an inner semiconducting casing 24 which, in turn, is surrounded by an extruded insulation layer 26. This layer is surrounded by an external semiconducting layer 28. The cable used as a winding in the preferred embodiment has no metal shield and no external sheath.

Preferably, at least two of these layers, and most preferably all of them, has equal thermal expansion coefficients. Hereby is achieved the crucial advantage that in case of thermal motion in the winding, one avoids defects, cracks or the like.

Figure 4 shows a first embodiment of a rotating asynchronous converter 30 according to the present invention. The rotating asynchronous converter 30 is used

for connection of AC networks with equal or different frequencies. The converter 30 comprises a first stator 32 connected to a first AC network (not disclosed) with a first frequency f_1, and a second stator 34 connected to a second AC network (not disclosed) with a second frequency f_2. In the disclosed embodiment the stators 32, 34 are three phase stators 32, 34 comprising three windings each, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation. The windings can also be formed of a cable of the type disclosed in figure 3. The converter 30 also comprises a rotor means 36 which rotates in dependence of the first and second frequencies f_1, f_2. In the disclosed embodiment the rotor means 36 comprises two electrically and mechanically connected three phase rotors 36_1, 36_2, which are concentrically arranged in respect of said stators 32, 34. The converter 30 also comprises an auxiliary device 38 connected to said rotors 36_1, 36_2 for starting up of the rotors 36_1, 36_2 to a suitable rotation speed before connection of said converter 30 to said AC networks. Each rotor 36_1, 36_2 comprises a low voltage winding (not disclosed). When the first stator 32 is connected to a three phase AC network with the frequency f_1 and the second stator 34 is connected to a three phase AC network with the frequency f_2, the rotors 36_1, 36_2 will rotate with the frequency $(f_1-f_2)/2$ and the stator current has the frequency $(f_1+f_2)/2$. The efficiency with such a converter will be very high (~99%) for small frequency differences due to the fact that all power is transmitted as in a transformer. Assuming $f_1<f_2$, a proportion $\frac{f_1-f_2}{f_2}$ of the power is transmitted mechanically and the remainder $\frac{f_1}{f_2}$

of the power is transmitted by transformer action. Mechanical power is only consumed to maintain the rotation.

In figure 5 there is disclosed a second embodiment of the rotating asynchronous converter 40 according to the present invention. The rotating asynchronous converter 40 is also used for connection of AC networks with equal or different frequencies. The converter 40 comprises a first stator 42 connected to a first AC network (not disclosed) with a first frequency f_1, and a second stator 44 connected to a second AC network (not disclosed) with a second frequency f_2. In the disclosed embodiment the stators 42, 44 are three phase stators 42, 44 comprising three windings each, wherein each winding can be of the type described in connection to figure 4. The converter 40 also comprises a rotor means 46 which rotates in dependence of the first and second frequencies f_1, f_2. In the disclosed embodiment the rotor means 46 comprises only one rotor 46 concentrically arranged in respect of said stators 42, 44. Said rotor 46 also comprises a first loop of wire 48 and a second loop of wire 50, wherein said loops of wire 48, 50 are connected to each other and are arranged opposite each other on said rotor 46. The loops of wire 48, 50 are also separated by two sectors 52_1, 52_2, wherein each sector 52_1, 52_2 has an angular width of α. The converter 40 also comprises an auxiliary device (not disclosed) connected to said rotor 46 for starting up of the rotor 46 to a suitable rotational speed before connection of said converter 40 to said AC networks. To compensate for the frequency difference Δf, the rotor 46 only needs to rotate with the frequency $f_R = \frac{\pi-\alpha}{\pi} \cdot \frac{\Delta f}{4}$, wherein $\Delta f = |f_1-f_2|$. For $\alpha=\pi/4$ this means $f_R = \frac{3\Delta f}{16}$, i.e. a very low rotational frequency. The main advantages with this embodiment are the low rotational frequency and the use of only one rotor.

In figure 6 there is disclosed a first embodiment of a generator device 60 with variable rotational speed according to the present invention. The generator device 60 comprises a stator 62 connected to an AC network (not disclosed) with a frequency f_2 and a first cylindrical rotor 64 connected to a turbine 66, which rotates with a frequency f_1. The generator device 60 comprises also a rotor means 68 which rotates in dependence of the frequencies f_1, f_2. The stator 62 and said first cylindrical rotor 64 each comprises at least one winding (not disclosed). Each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation. Each winding can in another embodiment also comprise a cable of the type disclosed in figure 3. The rotor means 68 comprises two electrically and mechanically connected rotors 68_1, 68_2, which rotors 68_1, 68_2 are hollow and arranged concentrically around said stator 62 and said cylindrical rotor 64. The stator 62 in the disclosed embodiment has a cylindrical shape. The rotors 68_1, 68_2 each comprises a low voltage winding (not disclosed) and they are rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation. The frequency of the rotor current will be $(f_1+f_2)/2$ when the generator device 60 is in operation. This generator device 60 is now disconnected from the power frequency and can be operated with the frequency as an optimizeable parameter. This generator device 60 will also give a better efficiency and power matching than a conventional generator.

In figure 7 there is disclosed a second embodiment of the generator device 70 according to the present invention. The generator device 70 comprises a stator 72 connected to an AC network (not disclosed) with a frequency f_2 and a first cylindrical rotor 74 connected to a turbine 76, which rotates with a frequency f_1. The

generator device 70 also comprises a rotor means 78 which rotates in dependence of the frequencies f_1, f_2. The stator 72 and said first cylindrical rotor 74 each comprises at least one winding (not disclosed). The winding can be of the types which were mentioned in the description in connection to figure 6. The rotor means 78 comprises a first rotor 78_1 and a second rotor 78_2, which rotors 78_1, 78_2 are electrically and mechanically connected to each other. The first rotor 78_1 is hollow and arranged concentrically around said first cylindrical rotor 74 and said second rotor 78_2 is cylindrical and surrounded by the stator 72. The first and second rotors 78_1, 78_2 of said rotor means 78 each comprises a low voltage winding and said rotors 78_1, 78_2 are rotating with the frequency $(f_1-f_2)/2$ when said generator device 70 is in operation. The stator 72 is hollow and arranged around said second rotor 78_2. This generator device 70 works in the same way and has the same advantages as the generator device 60 disclosed in figure 6.

The disclosed embodiments only show connection of three phase networks, but the invention is also applicable for connection of a three phase network, wherein one stator has a one/two phase application. The invention can also be used for connection of a three phase network and a one/two phase network, wherein one stator having a three phase application is connected via a Scott-connection or another symmetrical connection to a one/two phase network. The invention is also applicable to more than two stators and rotor parts to connect more than two AC networks. The only condition is that only two not synchronous networks are connected.

The invention is not limited to the embodiments described in the foregoing. It will be obvious that many different modifications are possible within the scope of the following claims.

CLAIMS

1. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2, and in that at least one of said stators each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

2. The rotating asynchronous converter according to Claim 1, **characterized in** that at least one of said semiconducting layers has in the main equal thermal expansion coefficient as said solid insulation.

3. The rotating asynchronous converter according to Claim 2, **characterized in** that the potential of the inner one of said layers is substantially equal to the potential of the conductor.

4. The rotating asynchronous converter according to Claim 2 or 3, **characterized in** that an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

5. The rotating asynchronous converter according to claim 4, **characterized in** that said outer layer is connected to a specific potential.

6. The rotating asynchronous converter according to Claim 5, **characterized in** that said specific potential is ground potential.

7. The rotating asynchronous converter according to any one of the Claims 1, 2, 3, 4, 5, or 6, **characterized in**

that at least two of said layers have substantially equal thermal expansion coefficients.

8. The rotating asynchronous converter according to any one of the preceding Claims, **characterized in** that said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

9. The rotating asynchronous converter according to any one of the preceding Claims, **characterized in** that each of said two layers and said solid insulation is fixed connected to adjacent layer or solid insulation along substantially the whole connecting surface.

10. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of said first and second frequencies f_1, f_2, and in that said stators each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor,

- each conductor comprises a number of strands
- around said conductor is arranged an inner semiconducting layer,
- around said inner semiconducting layer is arranged an insulating layer of solid insulation, and
- around said insulating layer is arranged an outer semiconducting layer.

11. The rotating asynchronous converter according to Claim 10, **characterized in** that said cable also comprises a metal shield and a sheath.

12. The rotating asynchronous converter according to Claim 11, **characterized in** that the cable has a diameter comprised in the approximate interval 20-250 mm and a conductor area comprised in the approximate interval 80-3000 mm^2.

13. The rotating asynchronous converter according to any one of Claims 1-12, **characterized in** that said rotor means comprises two electrically and mechanically connected rotors, which are concentrically arranged in respect of said stators.

14. The rotating asynchronous converter according to Claim 13, **characterized in** that said converter also comprises an auxiliary device connected to said rotors for starting up of the rotors to a suitable rotation speed before connection of said converter.

15. The rotating asynchronous converter according to Claim 14, **characterized in** that said rotors each comprises a low voltage winding, and in that said rotors are rotating with the frequency $(f_1-f_2)/2$ and the stator current has the frequency $(f_1+f_2)/2$ when said converter is in operation.

16. The rotating asynchronous converter according to any one of Claims 1-11, **characterized in** that said rotor means comprises only one rotor concentrically arranged in respect of said stators.

17. The rotating asynchronous converter according to Claim 16, **characterized in** that said rotor comprises a first loop of wire and a second loop of wire, wherein said loops of wire are connected to each other and are arranged opposite each other on said rotor and separated by two sectors, wherein each sector has an angular width of α.

18. The rotating asynchronous converter according to Claim 17, **characterized in** that said converter also comprises an auxiliary device connected to said rotor for starting up of the rotor to a suitable rotational speed before connection of said converter, and in that said rotor is rotating with the frequency $f_R = \frac{\pi-\alpha}{\pi} \cdot \frac{\Delta f}{4}$, wherein $\Delta f = |f_1-f_2|$.

19. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second

stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2, and in that said stators each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and also comprising an insulation system, which in respect of its thermal and electrical properties permits a voltage level in said rotating asynchronous converter exceeding 36 kV.

20. A generator device with variable rotational speed, wherein the generator device comprises a stator connected to an AC network with a frequency f_2, a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1, **characterized in** that said generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2, and in that said stator and said first cylindrical rotor each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

21. The generator device according to Claim 20, **characterized in** that at least one of said semiconducting layers has in the main equal thermal expansion coefficient as said solid insulation.

22. The generator device according to Claim 21, **characterized in** that the potential of the inner one of said layers is substantially equal to the potential of the conductor.

23. The generator device according to Claim 21 or 22, **characterized in** that an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

24. The generator device according to Claim 23, **characterized in** that said outer layer is connected to a specific potential.

25. The generator device according to Claim 24, **characterized in** that said specific potential is ground potential.

26. The generator device according to any one of Claims 20-25, **characterized in** that at least two of said layers have substantially equal thermal expansion coefficients.

27. The generator device according to any one of Claims 20-26, **characterized in** that said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

28. The generator device according to any one of claims 20-27, **characterized in** that each of said two layers and said solid insulation is fixed connected to adjacent layer or solid insulation along substantially the whole connecting surface.

29. A generator device with variable rotational speed, wherein the generator device comprises a stator connected to an AC network with a frequency f2, a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1, **characterized in** that said generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2, and in that said stator and said first cylindrical rotor each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor,

- each conductor comprises a number of strands,
- around said conductor is arranged an inner semiconducting layer,
- around said inner semiconducting layer is arranged an insulating layer of solid insulation, and
- around said insulating layer is arranged an outer semiconducting layer.

30. The generator device according to Claim 29, **characterized in** that said cable also comprises a metal shield and a sheath.

31. The generator device according to Claim 30, **characterized in** that the cable has a diameter comprised in the approximate interval 20-250 mm and a conductor area comprised in the approximate interval 80-3000 mm^2.

32. The generator device according to any one of Claims 20-31, **characterized in** that said rotor means comprises two electrically and mechanically connected rotors, wherein said rotors are hollow and arranged concentrically around said stator and said cylindrical rotor.

33. The generator device according to Claim 32, **characterized in** that said rotors of said rotor means each comprises a low voltage winding, and in that said rotor is rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation.

34. The generator device according to Claim 33, **characterized in** that said stator has a cylindrical shape.

35. The generator device according to any one of Claims 20-31, **characterized in** that said rotor means comprises a first rotor and a second rotor, which rotors are electrically and mechanically connected, wherein said first rotor is hollow and arranged concentrically around said first cylindrical rotor, and said second rotor is cylindrical.

36. The generator device according to Claim 35, **characterized in** that said first and second rotors of said rotor means each comprises a low voltage winding, and in that said first and second rotors are rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation.

37. The generator device according to Claim 36, **characterized in** that said stator is hollow and arranged around said second rotor.

38. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for connection of not synchronous three phase networks with equal rating frequencies.

39. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for connection of three phase networks with different frequencies.

40. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 as a series compensation in long distance AC transmission.

41. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for reactive power compensation.

Fig. 1

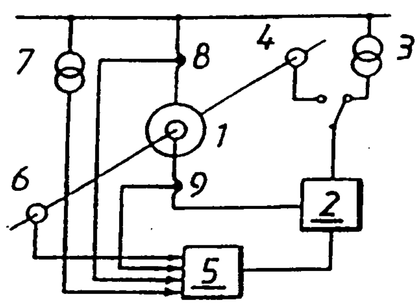


Fig. 2

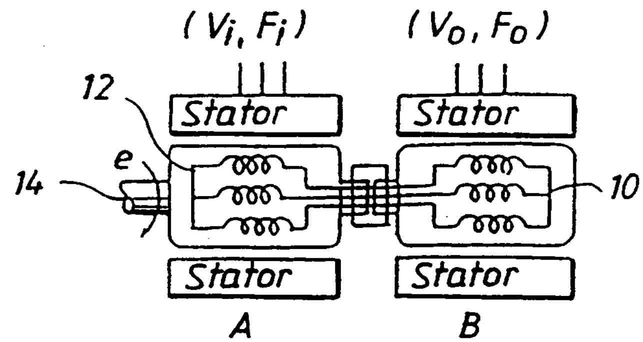


Fig. 3

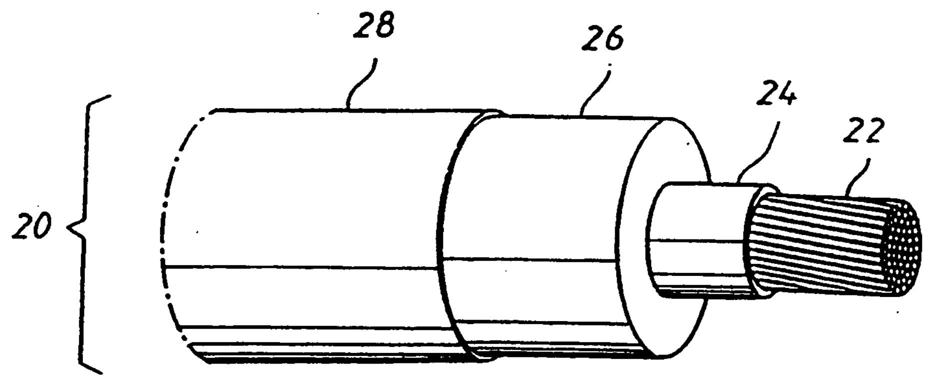


Fig. 4

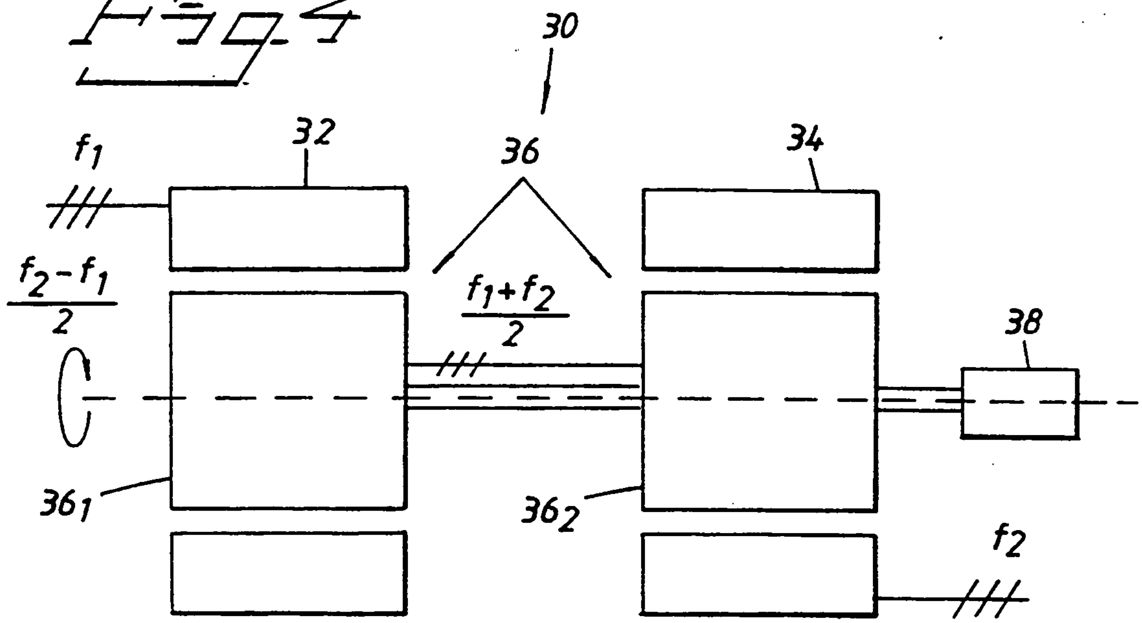

30
32
36
34
f_1
$\frac{f_2-f_1}{2}$
$\frac{f_1+f_2}{2}$
38
36_1
36_2
f_2

Fig. 5

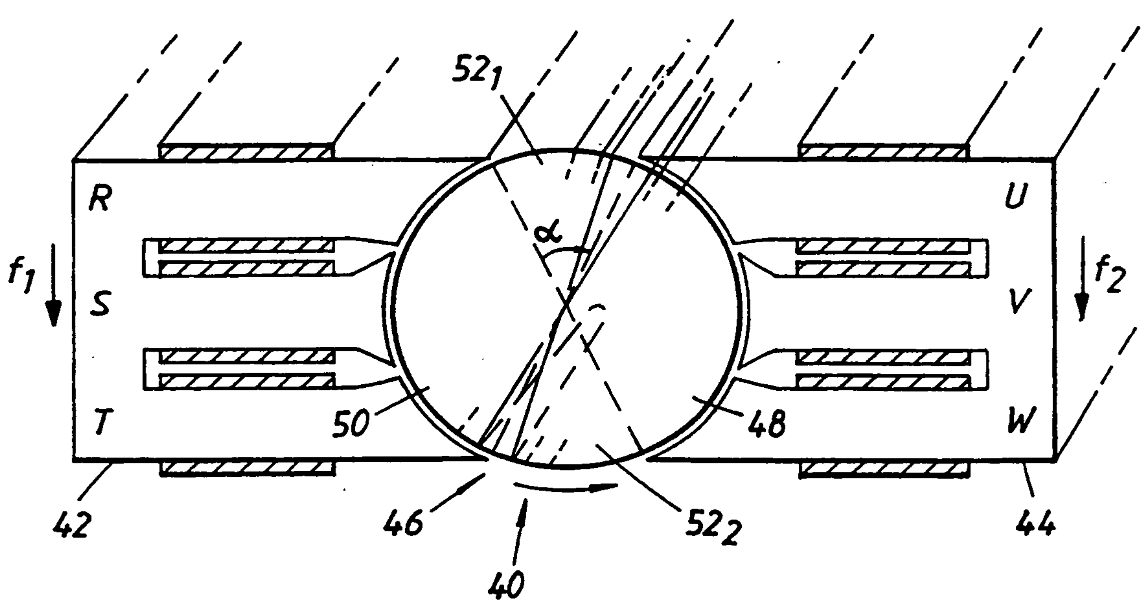
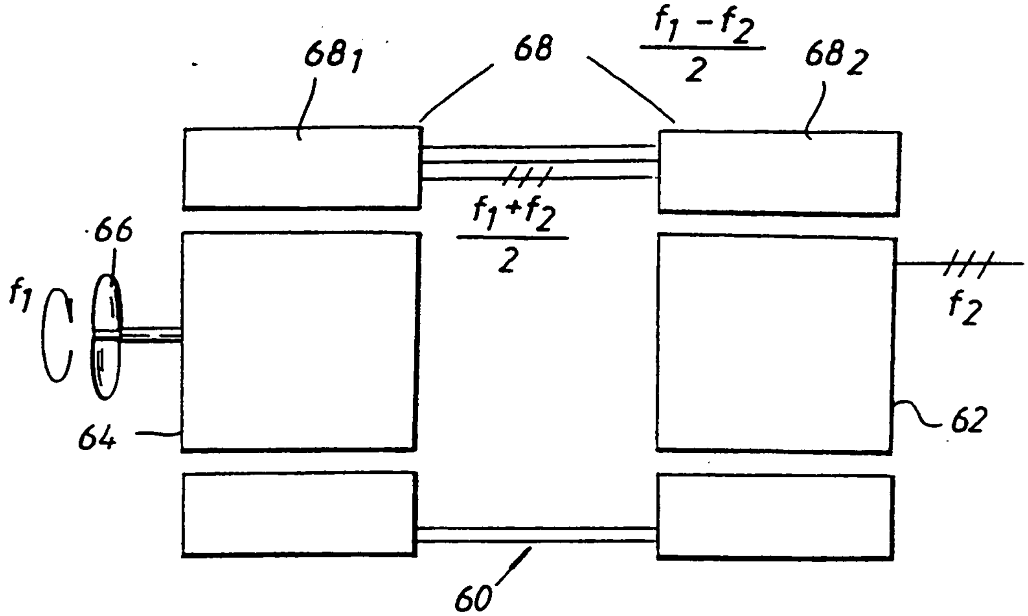

52_1
R
S
T
U
V
W
f_1
f_2
α
50
48
42
46
52_2
44
40

Fig. 6


68_1
68
$\frac{f_1 - f_2}{2}$
68_2
$\frac{f_1 + f_2}{2}$
66
f_1
f_2
64
62
60

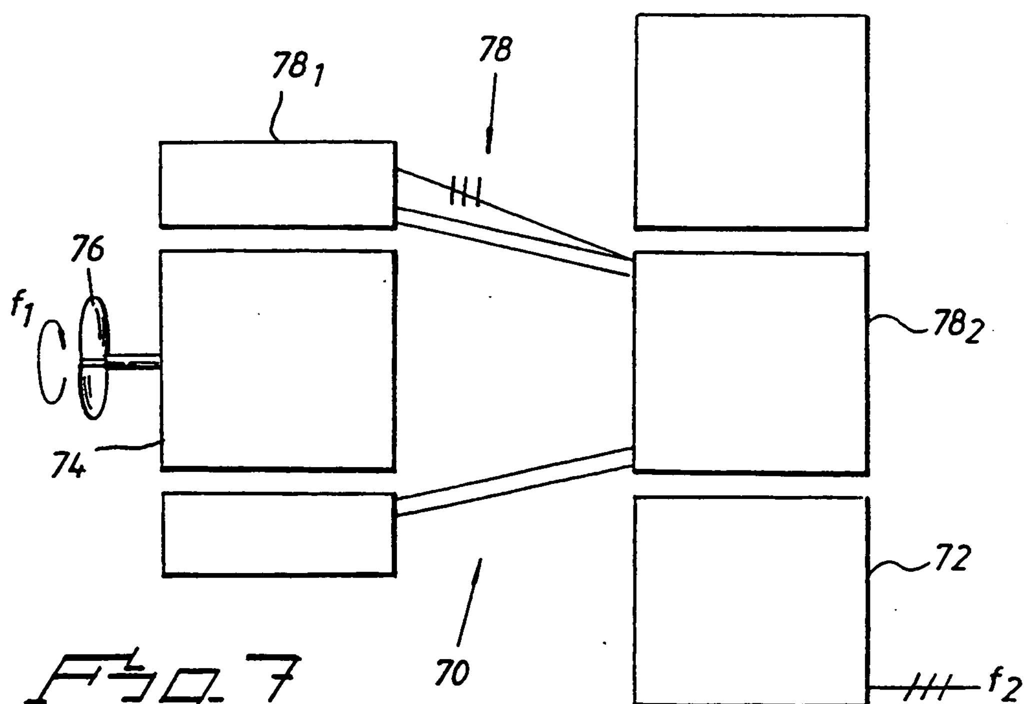

78_1
78
76
f_1
78_2
74
72
70
f_2

Fig. 7

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00890

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02J 16/00, H02K 47/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02J, H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0739087 A2 (RUNKLE, MARK ANDREW ET AL.), 23 October 1996 (23.10.96), abstract --	1-18,20-41
A	WO 9534117 A1 (ROESEL, JOHN F. ET AL.), 14 December 1995 (14.12.95), abstract --	1-18,20-41
A	US 4517471 A (K. SACHS), 14 May 1985 (14.05.85) --	1-18,20-41
A	US 4179729 A (W.E. STANTON ET AL.), 18 December 1979 (18.12.79), abstract --	1-18,20-41

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 1997	13.11.97
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anna Theander Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00890

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5036165 A (R.K. ELTON ET AL.), 30 July 1991 (30.07.91), abstract --	1-18,20-41
A	EP 0503817 A1 (HUARTE FRANCES ET AL.), 16 Sept 1992 (16.09.92), abstract --	1-18,20-41
A	US 3975646 A (LEE A. KILGORE ET AL.), 17 August 1976 (17.08.76), abstract --	1-18,20-41
P	EP 0749190 A2 (RUNKLE, MARK ANDREW), 18 December 1996 (18.12.96), abstract --	1-18,20-41
E	WO 9723940 A1 (THOMASSEN, KARL A.), 3 July 1997 (03.07.97), page 4, line 21 - line 26 -- --------	1-18,20-41

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE97/00890

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 19
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

See next sheet!

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Claims 19 defines a rotating asynchronous converter, having the capability to operate at voltages in excess of 36 kV. No special technical features are defined that provide this capability.

According to PCT/Guidelines/2/chapter 3.7 no special efforts need be made for searching unduly wide or speculative claims, beyond the extent to which they are supported by the description.

Since no further methods to achieve a rotating asynchronous converter capable to operate at voltages in excess of 36 kV are disclosed in the description, other than those already defined in claims 1-18, no meaningful search can be carried out regarding claim 19.

Therefore this claims is considered unsearchable.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 97/00890

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		NO 955282 A	23/06/97